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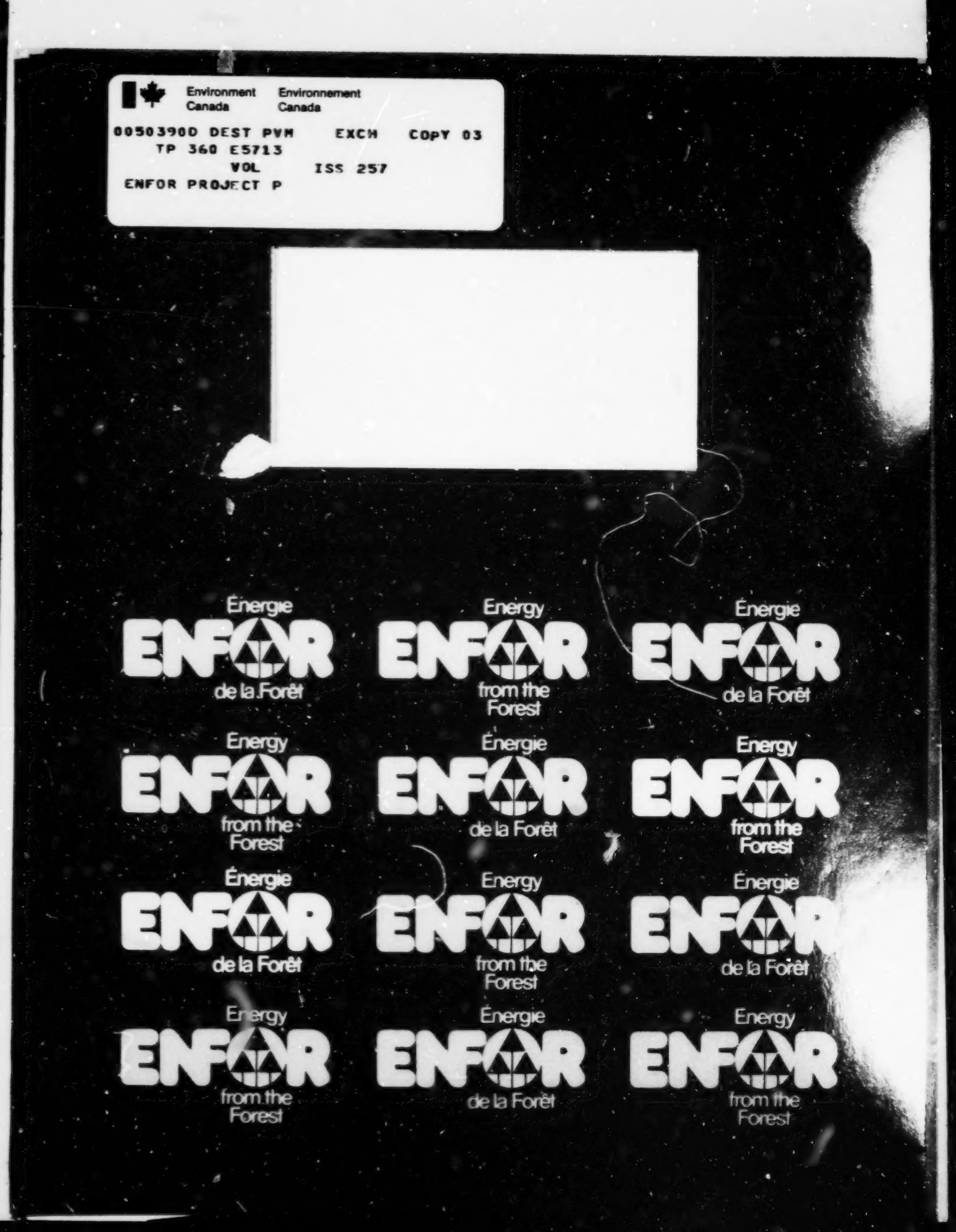

Contractor's Final Report [1/]
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ENFOR Project P-257

Silvicultural Treatments to Maximize Biomass Production in Aspen Stands

by

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May 1984

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Silvicultural Treatments to Maximize Biomass Production in Aspen Stands

by

B.J. Horton, Horton Forestry Services Ltd.

ABSTRACT

Aspen, the common "weed tree" of the Boreal Forest, reproduces by root suckers after logging or fire, forming clones which average some 0.1 ha. in area. Superior clones can be several times more productive than inferior, considering biomass, stem size, disease resistance etc. Methods for classifying clones were tested in Petawawa stands of trembling and largetooth aspen. Treatments designed to expand good clones and inhibit poor clones were applied experimentally in mature and immature stands. First-year results proved promising in terms of expandability of favoured clones.

INTRODUCTION

RATIONALE

Aspen in Ontario comprises a very large but scarcely exploited source of wood which cannot be ignored in any serious program of biomass production from the forest. While natural stands of aspen have the potential to increase forest production several fold, they are often characterized by poor stocking, overmaturity or uneconomic species mixtures. The problem is how to remedy these deficiencies by appropriate silvicultural methods. These stands exist, ready made, and managing them for biomass production represents a problem and an opportunity in utilization of the forest resource for energy that is complementary to, and not less significant than hybrid poplar management on agricultural soils.

In the context of forest renewal, aspen regeneration (predominantly from root suckering) is practically omnipresent, occurring to some degree in almost all upland areas subjected to logging or wildfire. Until recently, forest management has emphasized removing it to favour preferred conifers, particularly on planted sites. So there has been little or no interest in improving aspen regeneration experimentally or operationally. However, as ENFOR Report P-30(2)(Horton 1981) outlines, aspen suckering is readily available at no or minimal silvicultural cost, but is very variable in quality and easily manipulated in quantity. It can provide much greater yields than other native species on most upland sites. Moreover, the prospect of increasing aspen utilization in biomass and conventional (pulpwood, plywood, particle board) terms argues in favour of concerted silvicultural testing -- and this study provides an appropriate first effort.

OBJECTIVES

To maximize biomass yield of natural aspen stands by:

- developing, testing and demonstrating silvicultural treatments to favour selected superior clones for major genetic gains through higher quality reproduction;

- assessing effects of initial stocking on biomass yield and testing silvicultural treatments to maximize production.

SCOPE OF STUDY

The project is located at the Petawawa National Forestry Institute in typical stands of mature and immature trembling aspen (Populus tremuloides Michx.) and largetooth aspen (P. grandidentata Michx.).

This contract and report cover the establishment and first-year assessment of the project. Subsequent assessment of the results of silvicultural treatments will be carried out by staff of the Institute.

The project includes a clone classification methodology plus studies designed to compare clones as to regenerative capacity and growth as controlled by spacing. These are:

Study 1

- experimental treatments to favour regeneration of superior clones and inhibit that of inferior clones. It involves replicated plots in mature and immature stands (stands 1 and 3 respectively).

Study 2

- demonstration regeneration treatments to improve quantity and quality of stocking in an understocked mature aspen area (Stand 2).

Study 3

- a juvenile spacing experiment involving 6 good and 6 poor clones of immature trembling aspen (Stand 3).

DESCRIPTION OF STUDY AREAS

The studies are located in compartment 56 of the PNFI on deep, fine sands of outwash origin. Stands 1 and 2 are mature and predominantly stocked with a patchwork mixture of trembling and largetooth aspen clones. At 70 years of age, the weaker clones are starting to break up, allowing development of a scattered understorey of red maple, weak aspen and deciduous shrubs. Stand 1, the main locale of Study 1, is well stocked and situated on a lower terrace which constitutes a better quality site. In contrast, Stand 2 (Study 2) is irregularly stocked and of poorer quality, being on a drier upper terrace.

The immature Stand 3 originated from a fire in 1964 which swept through

parts of what are now labelled Stands 1 & 2, forming generally dense regeneration of the two aspen species.

Figures 1,2 & 3 show the layout of each study area.

CLONE CLASSIFICATION STUDY

CLONE IDENTIFICATION

Criteria for differentiating aspen clones have been documented by Barnes 1966, 1969, Kemperman 1977, and others. These were applied to the 8 ha. area of stand 1 to test the feasibility of identifying and mapping clones. The features, grouped into four general categories, are listed below together with comments on their practicality. They apply to both aspen species.

1. Tree Quality Features:

- Average d.b.h. of dominant stems - varies markedly between clones and is consistent within clones.

- Average dominant height- varies markedly between clones, is consistent within clones but is not necessarily correlated with diameter growth.

- Stem form- the degree of stem crook or sweep varies between clones irrespective of stem growth.

- Disease susceptibility - the incidence, relative abundance and general stem location of conks or cankers varies between clones and is reasonably consistent within clones.

- Crown vigour - the degree of crown dieback (proportion of dead branches) and general crown size vary between clones.

2. Phenological Features:

- Leaf flush - date of flushing and time of early leaf development vary between many clones. In some the early leaf colour tone is noticeably different.

- Leaf fall - the times of colouring and fall vary between many clones.

- Flowering time - clonal differences exist but variations in flower incidence and abundance plus visibility difficulties in tree crowns make this impractical.

3. Morphological Features:

Sex - clones are male or female but the same problems encountered with flowering time apply.

Leaf shape and dentation - clonal variation occurs but leaves are usually inaccessible.

Crown shape - this is largely a function of branch angle and length and is too subjective to be useful.

Branch angle - varies between clones but is only useful in extreme cases.

Branch size - the same applies.

Branch stub retention - a combined result of branch size and tree vigour, this is useful in clones with large branches. It may correlate with disease incidence.

Bark features - bark roughness - the degree and height of fissuring and branch scar patterns vary noticeably between many clones but uniqueness makes it difficult to apply.

4. Genetic Analysis:

Electrophoretic analysis of iso-enzymes is a definitive technique for clonal differentiation. This was tested in some putative clones from Stand 1 (Cheliak & Petel 1983). Chemical analysis-a costly technique-was not tested.

CLONE MAPPING

Many of the above features are not of practical use per se for field identification of clones. Some are not consistently definable or reliable, some are unique in character, many are too subjective for consistent application and several are confounded by interrelationship with other features. However, no clones are identical and, taken as a whole, the features do enable an experienced observer to differentiate putative (apparent) clones in general. Moreover, there are enough reliable traits available to permit mapping clonal boundaries, particularly in spring or fall when phenological differences are evident. For practical silvicultural purposes it is certainly possible to recognize superior, average and inferior clones. And for scientific purposes iso-enzyme analysis is feasible.

The clones of Stand 1 were mapped as exemplified in Figure 4. 86 clones were recognized in a total area of 8 ha., an average clone size of about 0.1 ha. A relative clone size classification is shown below:

Aspen Species	Tot. No. Clones	Clone Size Class (% of total) Smaller	Average (0.1 ha)	Larger
Trembling	42	76	19	5
Largetooth	44	52	16	32

Note the relative abundance of small clones in trembling and large clones in largetooth aspen.

The tree quality features are the most practical for clone classification. These were rated for each clone in Stand 1 as shown in Table 1A, using a simple scoring system which, when aggregated (1B), reflects overall relative quality (1C). The system can be variously adapted to any stand.

EXPERIMENTAL STUDIES

I. REGENERATION TREATMENTS IN PLOTS

The aim is to test treatments for improving and extending regeneration of selected clones.

Design

a) Mature Stand 1. Nine plots 40 x 40 m. square were located over the interface between contrasting pairs of clones, consisting of superior trembling aspen and inferior largetooth aspen clones in each case. Three treatments with three replications were assigned at random. Each plot involved a 20 x 20 m. treatment area with a 10 m. surround. Treatments were applied in May-June '83 as follows:

1. Control - clearcut all trees, removing whole trees with skidder

2. Clearcut as in 1., applying "Amitrol" to fresh cut stumps of the inferior clones (largetooth aspen)

3. "Root Tree" Method - clearcut all inferior clone stems and all except 3-4 premarked good stems of superior clone. Minimize logging disturbance and maximize slash within the inferior clone. The object is to allow only weak suckering to develop, then return after 2-3 years and remove the "root trees", which operation should destroy most existing weak suckers and encourage fresh suckering only from the superior clone.

b) Immature Stand 3 - Six plots 30 x 30 m. square were located over the interfaces between contrasting pairs of clones consisting of superior largetooth and inferior trembling aspen clones in each case (the reverse of Stand 1). Two treatments with 3 replications were assigned, the treatment area being 15 x 15 m. (7.5 m. surround). Treatments here were control vs. clearcut plus amitrol applied to trembling aspen stumps. The root tree method was not used.

Assessment

Permanent sample transects were laid out mechanically in each treatment plot at right angle to the clonal interface. In Stand 1 plots there are 4 transects, each consisting of 10 contiguous 2 x 2 m. quadrats ; in Stand 3 plots - 3 transects of 7 quadrats. Quadrat numbering starts near the large stake marking each plot, usually at the northeast corner (eg. 1-1 = transect 1, quadrat 1).

All stumps of cut trees of the original stand were mapped in each plot.

At the end of the first growing season following treatment all quadrats were assessed as to:

- number of suckers and collar sprouts by species
- tallest sucker and collar sprout by species.

Preliminary Results

a) Regeneration by Treatments

The results of first year assessments in Stand 1 are shown in Table 2. The density of aspen regeneration ranged from 12 to 40 thousand stems per hectare in the different plots. It is apparent that the trembling aspen was considerably more prolific than largetooth aspen in the first year. In general it was found that clonal effects were of overriding significance in determining sucker density. Simple analysis of variance at the 5 percent significance level determined that there was significant variation in sucker density of trembling aspen clones both among all plots and among plots within a treatment. The same was also true of the nine largetooth aspen clones. Analysis of variance was also carried out to compare the herbicide and root tree treatments with controls. The results of this analysis are contained in Table 3.

It is readily apparent from Tables 2 and 3 that the herbicide treatment was ineffective on largetooth clones in Stand 1. It was expected that the density of largetooth suckers in herbicide plots would be significantly less than that in the controls. However, the opposite was true in this case. Comparison of root tree plots with controls shows that attempts made to minimize suckering on the former were also ineffective.

It is important to note that the first year assessment is not necessarily indicative of the ultimate treatment results. On many of the plots there will be additional suckering occurring in coming years. There is also a possibility that the herbicide will have a latent effect on regeneration which will begin to show in the 1984 growing season.

The dominant height of trembling aspen root suckers was greater than that of the largetooth aspen clones on eight of nine plots.

Table 4 summarizes the first year assessment of clonal treatments in the immature Stand 3. The density of regeneration was generally much lower than that in the mature stand. Also, root collar sprouts represented a significant proportion of the regeneration in the young stand. Very few collar sprouts were found in the older stand where root suckering was predominant.

Again analysis of variance at the 95 percent confidence level determined that there was significant variation in the density of regeneration among both the trembling and largetooth aspen clones. In this case however, the herbicide treatment was apparently successful as there was significant variation in the numbers of trembling aspen stems between the herbicide and control treatments. This resulted mostly from the herbicides inhibiting the development of trembling aspen root collar sprouts (Table 4).

It is likely that a great deal of additional suckering will occur in the stand 3 plots in the coming year. This should provide more reliable results.

In the younger stand, the root collar sprouts were generally taller in the first year than root suckers. The largetooth aspen also tended to be taller than the trembling aspen regeneration.

b) Clonal Expansion

There is preliminary evidence from some Stand 1 plots on the potential for clonal expansion. This is exemplified in Figure 5 showing the distribution of sucker density by species along the sample transects of plot 2. Examination of pertinent plot data indicated that appreciable suckering of the desired clones (of trembling aspen in this stand) occurred up to 15 m. from the clonal interface, averaging approximately 7 m. This generally confirms the finding of Perala (1981). It means that an average clone covering 0.1 ha. would be capable of expanding 2 to 3-fold at each rotation, and a large clone of 1 ha could increase 50% accordingly.

Future Work

As to treatments, the "root tree" plots will require removal of residual root trees after year 3 (fall 1985). In the herbicide-treated plots of Stand 1 the amitrol was not sufficiently effective in the first season. Retreatment in 1984 is advocated, using either cacodylic acid or "Roundup" applied to re-cut stumps of the inferior clones in spring, or a directed foliar spray on the unwanted suckers in the summer.

Reassessments will be required in the autumns of 1984,85 and '87.

II. REGENERATION DEMONSTRATION IN BLOCKS

"Treatments

This is a pilot-scale test of three treatments - 1) the "root tree" method, 2) clearcutting alone and 3) clearcutting plus scarification - to compare their effectiveness in terms of quantity and quality of aspen regeneration. The parent stand (Stand 2) was a poorly stocked variant of Stand 1, located in a poorer (drier) site. Hypothetically, clearcutting alone should result in improved stocking of the regenerated stand. Scarification should further enhance stocking and the "root tree" technique should improve quality.

Treatments replicated 3 x were applied in August, 1983, randomly distributed among nine blocks as shown in Figure 2. This was too late to result in appreciable suckering in the current growing season.

Assessment

The permanent sampling system is also indicated in Figure 2. Twenty individual 2 x 2 m. quadrats are established along two lines in each block, randomly located on a stratified basis. Assessments are scheduled for 1984, 1985 and 1988.

III. JUVENILE SPACING PLOTS

a) Rationale - A great deal of variability in growth rates was observed among clones in an even-aged, 20-year-old stand (stand 3, same as in Study I). The clones were also variable in density; the faster growing clones were generally self-thinning at a higher rate. This study was designed to compare

the effect of juvenile spacing on the growth of the good versus poor clones of trembling aspen, the more important aspen species.

b) Design - Six fast-growing and six slow-growing clones were located on comparable sites within the stand (Fig. 3). Sample plots 400 square metres in size (20 x 20) were established within each clone. Three plots each of the fast and slow growing clones were spaced to 3 meters leaving selected stems. A 7.5 metre surround was also treated around these spacing plots. The remaining 3 plots within each group were designated as controls. Plots were treated in July, 1983.

c) Assessment - Diameter at breast height was measured on all trees within the plots before and after treatments where applicable. Heights were taken on 5 trees within each 2 centimetre diameter class. Comparable assessments should be made at five-year intervals (fall 1988,1993.).

DISCUSSION

Speculation on the efficacy of the "root tree" method would be premature at this point but two practical issues deserve mention. There is a risk of losing root trees to windfall; in these experiments two trees have already succumbed to an unusually severe summer windstorm. In selecting root trees there may be a problem with the erratic distribution of superior clones. To maintain reaonably even spacing of residuals it may be necessary to select superior stems regardless of clonal boundaries.

Further testing of appropriate herbicide applications to control suckering of poor clones is warranted. Stump treatment immediately after cutting was not adequate in these tests. Possibly basal spraying of trees before cutting or stump treatment following root suckering would be more effective. Confining the elimination of poor clones to good sites may be most feasible.

Preliminary results indicate that good clones can be selected and expanded effectively. For maximum effect this should emphasize moderate to good sites and small to average-sized clones.

The comparative results of these trials after a few years should indicate stocking requirements for maximum yields of biomass vs. quality logs and appropriate regeneration treatments to achieve those requirements.

TABLE 1

A. CLONAL RATING MATRIX

TRAIT	SCORE 0	1	2
Av. Dom Dbh (cm)	25-	30	35+
Av. Dom Ht. (m)	20-	21-24	25+
Stem Form	crooked	slightly crooked	straight
Disease Prone	High	Medium	Low
Crown Vigour (dieback)	50%+	30-40%	20%-

B. CLONAL RATING CLASSES

Total score	0-3	poor
	4-6	fair
	7-10	good

C. STAND 1. CLONE SUMMARIES

Species	Tot. No. Clones	Clone Ratings (% of Total) Poor	Fair	Good
T	42	17	52	31
L	44	25	50	25

TABLE 2. DENSITY AND HEIGHT OF ASPEN ROOT SUCKERS BY SPECIES AND TREATMENT - STAND 1

TREATMENT		CONTROL			HERBICIDE			ROOT TREE		
PLOT NO.		3	8	9	2	4	5	1	6	7
MEASURE										
STEMS PER HECTARE	1. Trembling	35.8	14.2	10.5	19.6	31.9	30.5	6.6	15.2	31.1
	Treatm't Av.		20.2			27.3			17.6	
1000	2. Largetooth	3.4	7.4	1.9	10.4	6.0	4.5	22.2	6.9	9.1
	Treatm't Av.		4.2			7.0			12.7	
	3. Total	39.2	21.6	12.4	30.0	37.9	35.0	28.8	22.1	40.2
	Treatm't Mean		24.4			34.3			30.4	
AVERAGE DOMINANT HEIGHT (cm)	1.Trembling	135.9	72.9	90.9	109.8	134.2	112.0	96.3	96.1	130.6
	Treatm't Av.		99.9			118.7			107.7	
	2. Largetooth	93.2	64.7	74.7	89.5	91.0	95.3	105.3	82.4	84.6
	Treatm't Av		77.5			91.9			90.8	

TABLE 3
ANALYSIS OF VARIANCE BETWEEN REGENERATION TREATMENTS AND CONTROLS * STAND 1

SPECIES	COMPARISON	
	HERBICIDE VS. CONTROL	ROOT TREE VS. CONTROL
Trembling	significant	insignificant
Largetooth	significant	significant

*Comparative ANOVA carried out on plot means at 5% significance level.

TABLE 4
DENSITY AND HEIGHT OF ASPEN REGENERATION BY SPECIES AND TREATMENT - STAND 3

	TREATMENT	CONTROL			HERBICIDE		
	PLOT	C2	C4	C5	C1	C3	C6
MEASURE							
STEMS PER HECTARE 1000	1. TREMBLING						
	a) Root Suckers	9.9	5.8	8.2	8.6	8.4	4.3
	Treatment Av.		8.0			7.1	
	b) Collar Sprouts	2.5	2.6	2.3	0.4	1.0	0.0
	Treatment Av.		2.5			0.5	
	c) Combined	12.4	8.4	10.5	9.0	9.4	4.3
	Treatment Av.		10.4			7.6	
	2. LARGETOOTH						
	a) Root Suckers	8.9	3.5	1.1	2.7	4.4	8.1
	Treatment Av.		4.5			5.1	
	b) Collar Sprouts	3.5	1.2	0.4	2.1	2.7	1.4
	Treatment Av.		1.7			2.1	
	c) Combined	12.4	4.7	1.5	4.8	7.1	9.5
	Treatment Av.		6.2			7.1	
	3. TOTAL						
	a) Root Suckers	18.8	9.3	9.3	11.3	12.9	12.4
	Treatment Av.		16.6			14.7	
AVERAGE DOMINANT HEIGHT (cm)	1. TREMBLING						
	a) Root Suckers	94.4	53.8	69.1	36.4	59.6	29.2
	Treatment Av.		72.4			44.7	
	b) Collar Sprouts	88.3	58.5	93.4	35.7	84.0	110.0
	Treatment Av.		80.1			62.5	
	2. LARGETOOTH						
	a) Root Suckers	59.7	49.4	33.7	50.9	74.1	62.6
	Treatment Av.		47.6			62.5	
	b) Collar Sprouts	104.3	49.8	141.0	76.8	89.8	76.1
	Treatment Av.		98.4			80.9	

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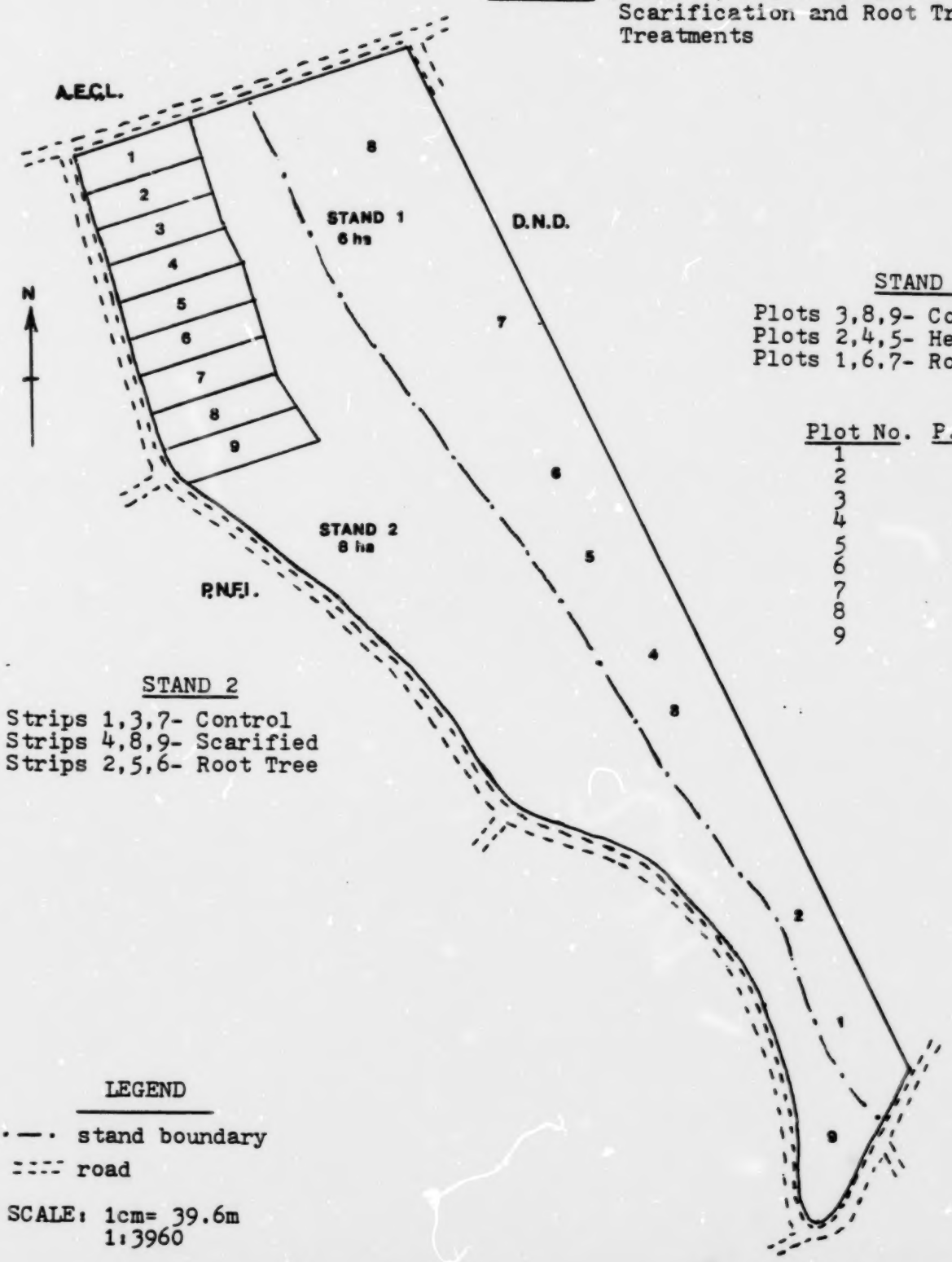
FIGURE 1 — ENFOR Project PN-83-6:
Improving Aspen Biomass Yield
Sturgeon Lake Plains- P.N.F.I. - 1983

STUDY 1 (stand 1)-Experimental Treatment of Clones to Improve Yield- Mature vs Immature Stands

STUDY 2 (stand 2)-Pilot Trials of Scarification and Root Tree Treatments



STAND 1

Plots 3,8,9- Control
Plots 2,4,5- Herbicide
Plots 1,6,7- Root Tree

Plot No.	P.S.P. No.
1	486
2	487
3	488
4	489
5	490
6	491
7	492
8	493
9	494

STAND 2

Strips 1,3,7- Control
Strips 4,8,9- Scarified
Strips 2,5,6- Root Tree

LEGEND

·—· stand boundary

:::: road

SCALE: 1cm= 39.6m
1:3960

FIGURE 2 - Stand 2

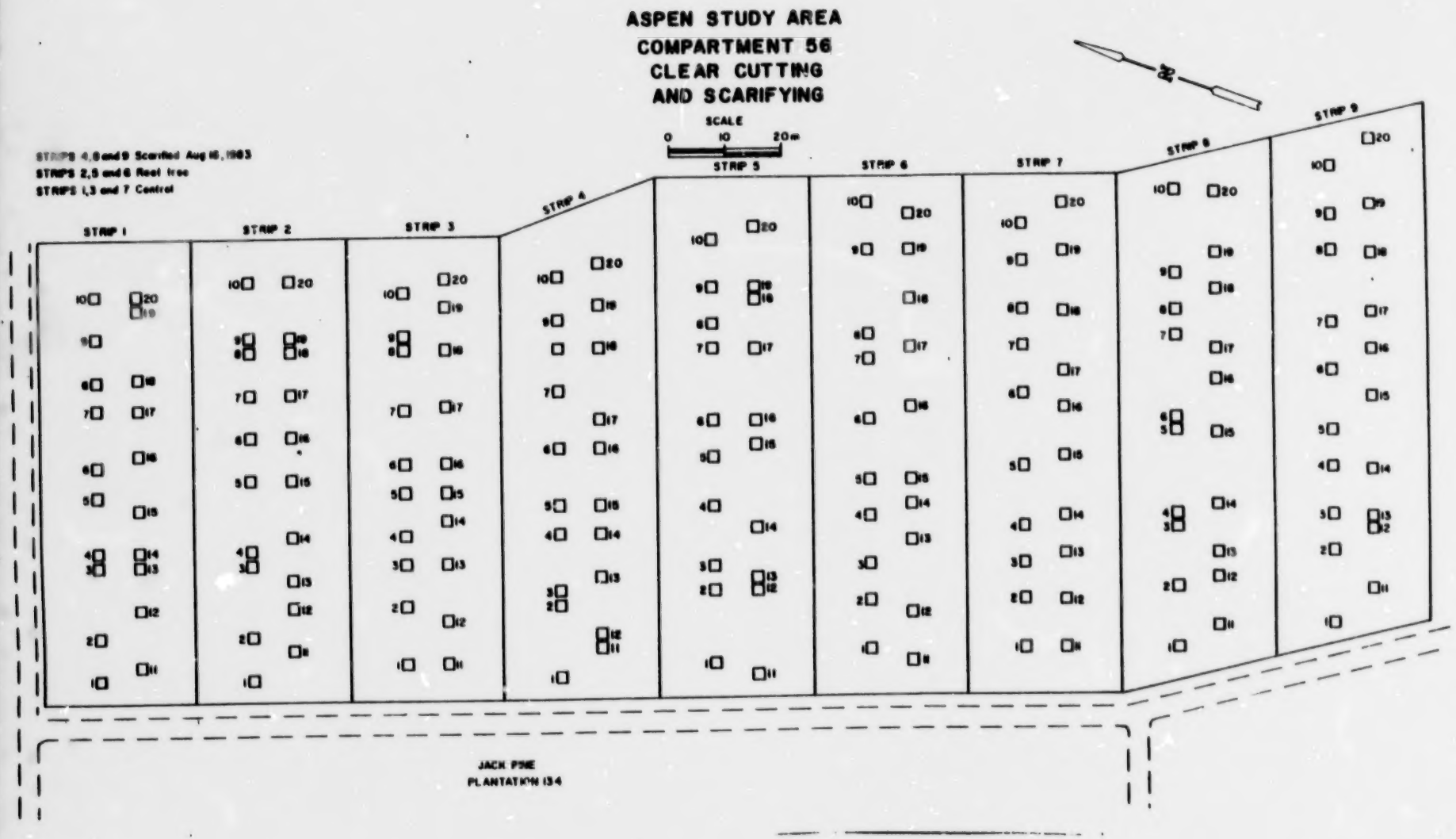


FIGURE 3 - Stand 3

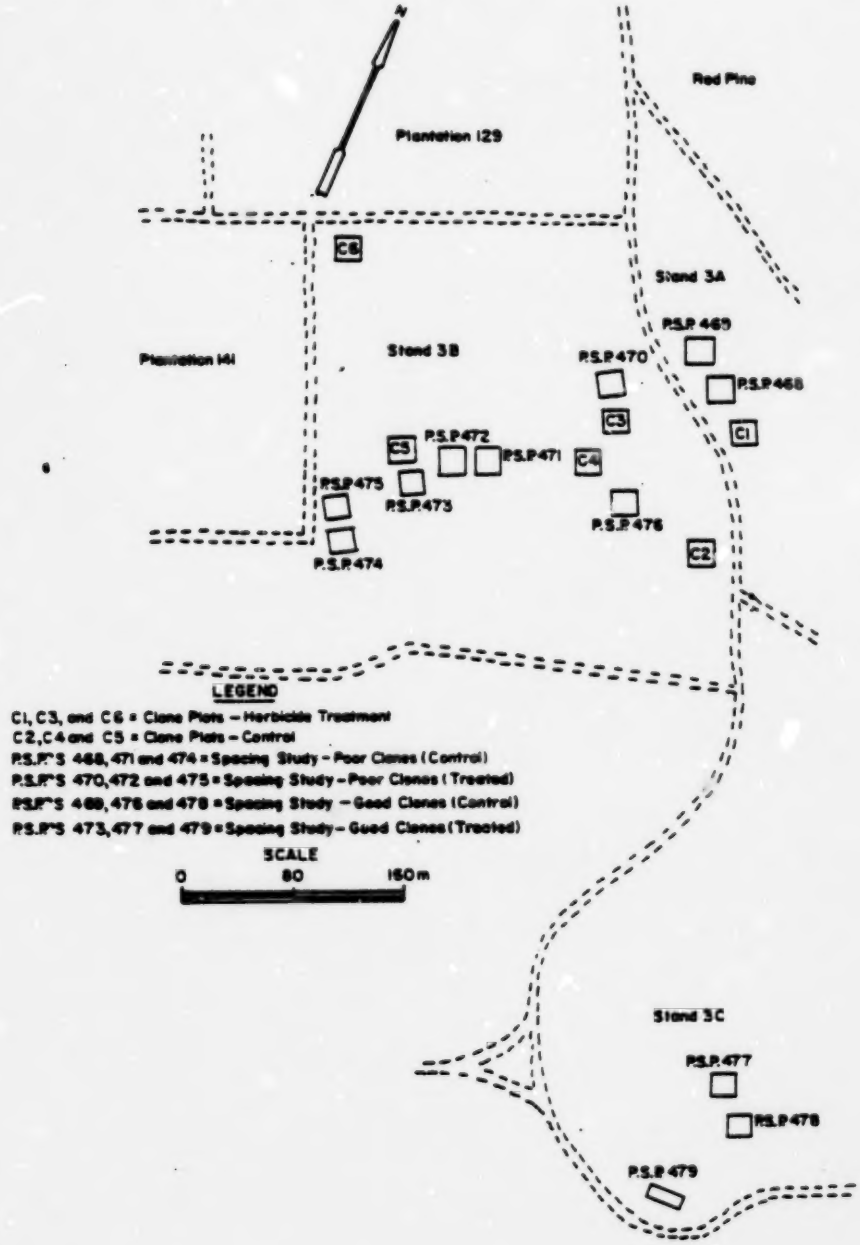


FIGURE 4- Sample clonal map-stand 1, 70 year old aspen

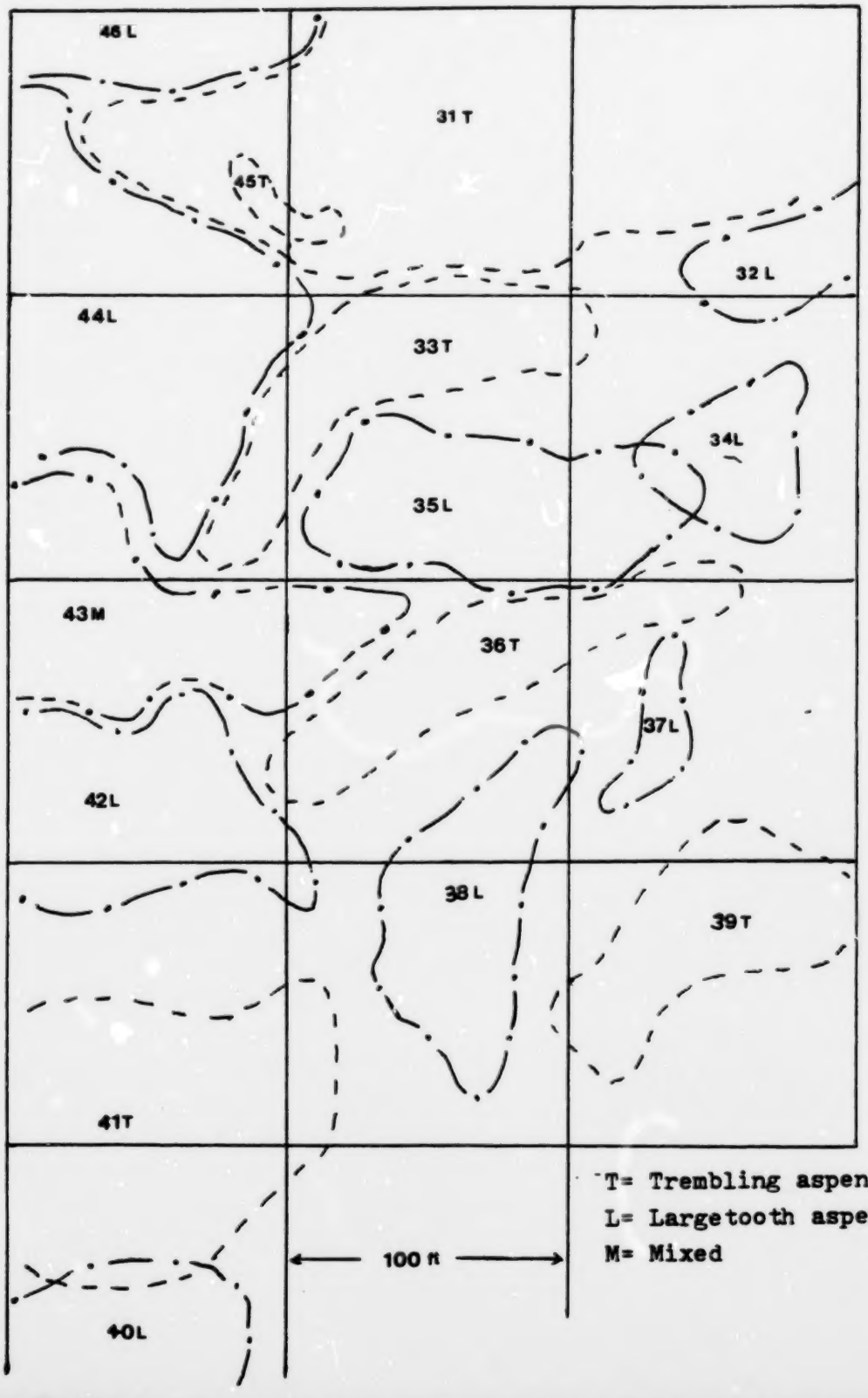
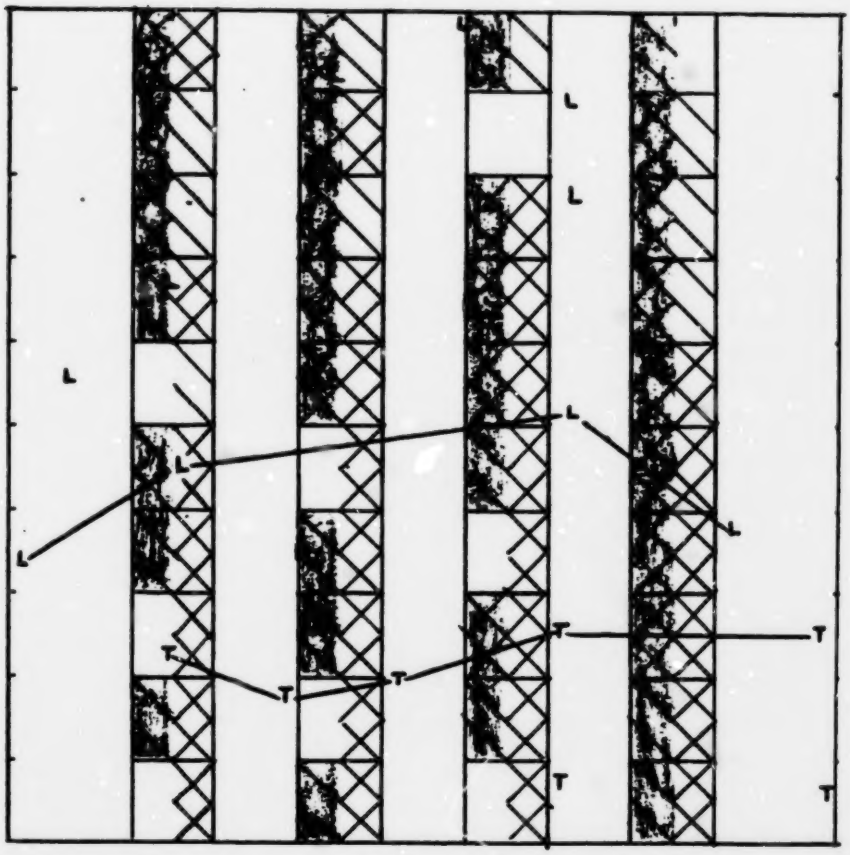


FIGURE 5 -Stump Location and Sucker Density- P.S.P. 487

LEGEND

1-4 stems per quadrat) Trembling
5+ " " ")
1-4 " " ") Largetooth
5+ " " ")



N

SCALE-1"=4 metres

T- Trembling aspen stump
L- Largetooth aspen stump

POOR

QUALITY

ORIGINAL